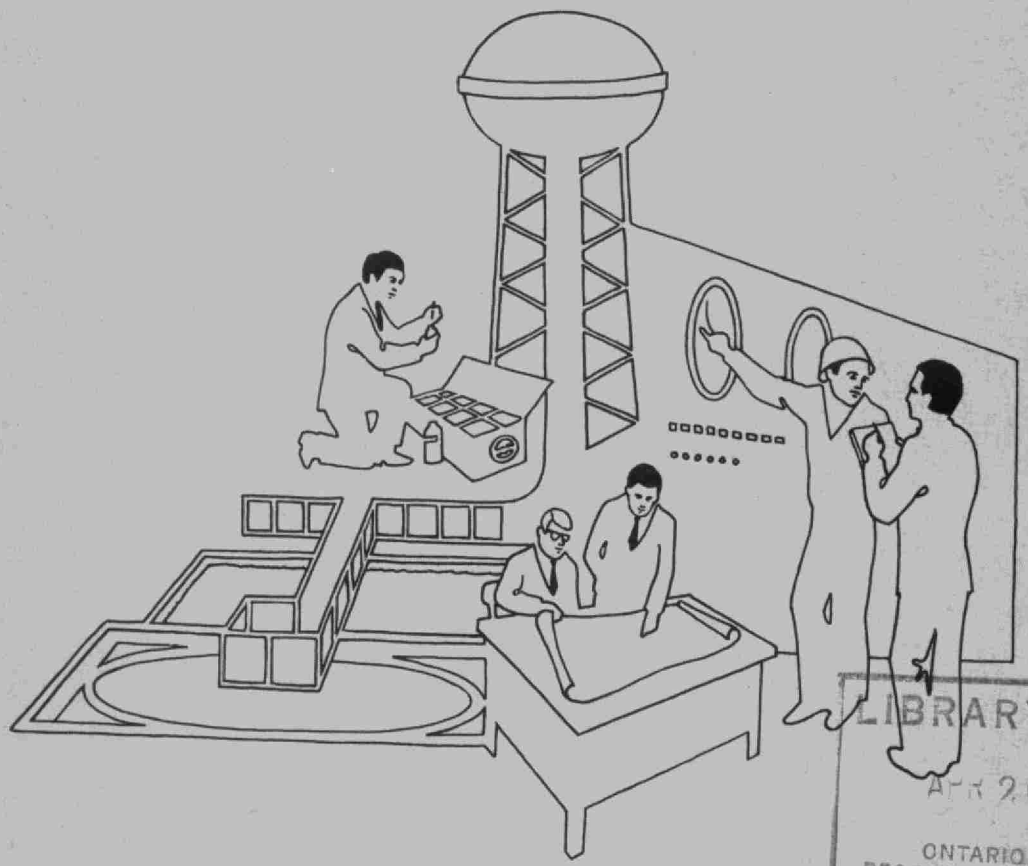
Water management in Ontario

Ontario Water Resources Commission

District Engineers Branch



THUNDER BAY REGIONAL OFFICE

REPORT ON

KAMINISTIKWIA RIVER FISH KILL - AUGUST, 1970

(MISSION CHANNEL)

KAMINISTIKWIA RIVER (MISSION CHANNEL) FISH KILL - AUGUST 25, 1970

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REPORT

Ontario Water Resources Commission

Municipality City of Thunder Bay Date of Inspection August 25, 1970

Re: Kaministikwia River (Mission Channel) - Fish Kill

Field Inspection by J. R. Marsh, District Engineer Report by J. R. Marsh, P. Eng.
B. F. Mason, Chemical Technologist

INTRODUCTION

On August 25, 1970, an anonymous caller contacted the Thunder Bay Regional Office by telephone at approximately 1:45 p.m. to report the presence of "hundreds" of dead fish in the Mission River "opposite the Ontario Hydro Steam Generating Station". No further comments relative to the report were presented.

The writer and Mr. B.F. Mason, Technologist, Division of Industrial Wastes, proceeded to the Mission River to investigate. The on-site investigation commenced at approximately 2:00 p.m. on August 25 and continued until approximately 6:30 p.m. the same afternoon. The Commission's vessel, Monitor II, was utilized during this investigation.

The following morning Mr. Mason and Mr. W.J. Grobelny, Technician, Division of Sanitary Engineering, returned to the Mission River, Abitibi Seawall area, for the purpose of resampling the water in the vicinity of the fish kill.

SUMMARY OF REPORT

As a result of a "moderate" fish kill in the Mission River adjacent to the Abitibi (Mission) Mill breakwall, the Thunder Bay Regional Office carried out field investigations on August 25 and 26, 1970, to determine the cause of this mortality. The investigations continued through September and October with the resulting report completed in November, 1970.

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The report concludes that waste discharges to the Kaministikwia watercourse between the McKellar channel and the new Highway 61 bridge can accumulate in the Mission channel during periods of low flow conditions. The fact that significant quantities of wastes are being discharged to the Kaministikwia River and that these can accumulate in the Mission River leads to severe oxygen depletion in the watercourse. In addition, benthic oxygen demand further depletes available life sustaining oxygen and the observed fish kill of August 25, 1970 resulted.

The Ontario Hydro controls the entire river flow. This greatly influences the route which the flow takes in passing to Lake Superior. In that the quantity of wastes discharged to the river is already exceedingly high, it appears that any reduction in flow below 600 c.f.s. further reduces the assimilation ability of the Kaministikwia River.

The physical characteristics of the watercourse also appear to play an important part in the total river impairment. Owing to the utilization of the river as a navigable waterway, the channel improvements for transportation may be contributing to the total degradation of the river environment. Other conflicting uses also appear evident and it would seem advisable that some discussion relative to these uses be initiated for the purpose of establishing water quality standards.

The fish kill observed on August 25 is completely predictable. It is recognized that similar mortalities will take place periodically unless changes relative to flows and waste inputs are effected at the time of critical conditions. The report suggests that a minimum river flow be established and that all existing waste discharges be monitored on a routine basis. Information pertaining to pollution abatement programs and changes in effluent

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characteristics should be tabulated for annual review. Finally, it is recommended that specific water quality standards be drafted to facilitate the implementation of pollution abatement programs within the Kaministikwia River watershed.

PERSONS INTERVIEWED OR CONTACTED

Mr. L. Culbert, Lakehead Harbour Police
Mr. A. Marcoux, Abitibi Paper Company (Mission Mill)
Mr. J. Crooks, Ontario Hydro
Mr. M. Northfeld, Ontario Hydro
Mr. P. Cormier, Ontario Hydro
Mr. L. Jeffers, Ontario Hydro
Mr. P. Dodgson, Ontario Hydro
Mr. D. McClelland, North Shore Supply
Mr. A. Elsie, Department of Lands and Forests
Mr. T. Timmerman, Department of Lands and Forests

INVESTIGATIONS

(a) August 25, 1970

Mr. Mason and the writer proceeded to the Ontario Hydro Steam Generating Plant wherein Mr. J. Crooks, Chief Operator, was contacted. When queried about the dead fish, Mr. Crooks was unable to confirm the report. However, Mr. Northfeld, Chemist, indicated that his laboratory records did note a recent chemical change in the quality of water in the Mission River. This change took place over a period of two to three days prior to the OWRC investigation on the 25th. A brief review of his records revealed that the change was holding on that day. A copy of the chemical results maintained by Hydro of the Generating Station raw water from the Mission River is appended. (See Appendix IV).

A tour of the Hydro property was undertaken in company with Mr. Northfeld. Visual observations of the Hydro operation and the water in the vicinity of the plant failed to reveal anything that could be related to a fish kill.

Mr. Mason and the writer proceeded to the Abitibi(Mission) Mill property and at approximately 2:40 p.m. interviewed Mr. A. Marcoux, Mill Manager.

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Mr. Marcoux was not able to provide any information relative to the fish kill report and gave the OWRC representatives permission to inspect the river from Company property. At 2:50 p.m., Mr. Marcoux, Mr. Mason and the writer were standing on the Company's Mission River Seawall observing the presence of approximately 100 dead fish. Fish samples retrieved from the water at this location and held for subsequent identification by the Thunder Bay Regional Office, revealed that suckers and herring were the only two species of fish appearing at this location.

Samples of the water were obtained at this time from the river in the vicinity of the largest concentration of dead fish as well as from two areas in the same reach of the river where dead fish were not present. Further samples were collected at random at several locations upstream in the main branch of the Kaministikwia River. A list of the stations sampled is appended. Also, the results are presented in the appended section in tabular and graphical form for ease of interpretation. (See Appendices I, II and III).

(b) August 26, 1970

During the morning of August 26, 1970 Regional Office staff repeated the sampling and testing of the water in the Mission River adjacent to the Abitibi Paper Company property. The investigation on this day did not cover any additional stations on the Mission or Kaministikwia Rivers. A visual inspection of the rivers from the mouth of the Mission to the new Highway 61 bridge suggested that the cause of the fish mortality had passed. Further, no subsequent fish kills were observed or reported following the investigations of August 25th and 26th.

FISH KILLS - KAMINISTIKWIA RIVER

Several fish kills have been reported in the past few years. Records reveal that during the summer of 1966, a mortality occurred largely as a result

of a period of particularly hot, dry weather. As the temperature of water increases, its ability to hold oxygen, or the dissolved oxygen solubility, decreases. On the basis of this known relationship and the fact that the water temperatures were exceedingly high for this watercourse in 1966, it was postulated that "lack of oxygen", levels of which were measured far below the acceptable, safe limit of 4.0 parts per million (ppm), was responsible for the 1966 fish kill. The investigator at that time further pointed out that the lack of life-sustaining oxygen could be due to the discharge of oxygen depleting wastes from the municipality and the industries as well as the high water temperatures. Both factors of temperature and pollution were apparently responsible. It is quite probable that cooler weather during the summer of 1966 would have been sufficient to prevent a fish mortality in the river. It follows as well that the lack of, or reduction, in oxygen depleting waste discharges, could also have prevented the kill.

In July, 1969, another fish kill was investigated by the Ontario Water Resources Commission's Regional Office. On this occasion "approximately 50 fish" succumbed to conditions which were related subsequently to water temperature, low flow and lack of dissolved oxygen. Prior to this fish kill, water temperatures in the Kaministikwia River were noted to be higher than normal. This temperature increase, which was capable of imposing a stress upon fish life, was reflecting high air temperatures, little rainfall and low river flow. The matter was further complicated by the discharge of an accidental spill of Kraft Mill wastes from the Great Lakes Pulp and Paper Company Ltd. The combination of the spill from the Kraft Mill, the high background waste loadings and the period of unfavourable water temperatures probably resulted in the observed fish mortality in 1969.

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Oxygen depletion in a watercourse can also be related to the bacterial communities within the environment. Benthic organisms, which contribute significantly to the organic degradation process, utilize oxygen. The amount of oxygen utilized by the organisms is proportional to the concentration of bacteria present which are in turn related to the amount of organic waste matter present.

The preceding clearly illustrates the importance of oxygen and temperature in maintaining fish life. The relationship between oxygen and lesser forms of aquatic life can also be clearly established. Furthermore, the generally accepted theories pertaining to life sustaining oxygen levels are no longer entirely valid in waters carrying a high pollutional load (Tarzwell). Under pollutional conditions, fish generally require more oxygen. At low dissolved oxygen levels, fish can succumb to concentrations of toxic materials which they could normally tolerate at higher dissolved oxygen levels. Therefore, environmental conditions can have a very definite bearing on the ability of fish to resist low oxygen levels. Such being the case, it is possible under particular environmental conditions to asphyxiate several species of fish at dissolved oxygen levels well above zero saturation.

The preceding merely indicates briefly the complexity of the problem as it relates to dissolved oxygen requirements for fishes. What must be recognized is that the occurrence of a fish kill not only signifies a loss of potential sport or commercial fishing, but an adverse change in the water environment. This change, while observed visually with the fish mortality, could in all likelihood have far reaching significance where the entire aquatic community is concerned. In total perspective, the ecology of a river is dependent upon the interreactions and interbehavioural patterns of all forms

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of life which make up the biological community. A destruction of the smallest or what might appear to be the least significant member of that community, could eventually produce a detrimental effect on the entire ecology. The ultimate, least desirable, consequence is a "dead" environment in which no assimilation of input wastes, regardless of the source, character and quantity, can take place.

RESULTS AND OBSERVATIONS

As indicated, other fish kills have occurred throughout the past few years in the Kaministikwia River. Generally speaking, the earlier fish kills have been related to either lack of oxygen or warm water temperatures or a combination of the two. On August 25, 1970, oxygen levels in the vicinity of the fish mortality were noted to be exceedingly low and water temperatures were elevated. Therefore, the initial investigations attempted to explore these aspects further. Without benefit of sample results, the first assumption, related to this mortality, was to draw a parallel to the earlier fish kills in the Kam River.

One factor, however, could not be satisfactorily explained. The temperatures noted during the investigation and presented in the attached appendix revealed that the water was cooler in the vicinity of the kill than noted in the upper reaches of the river, i.e. near the new Highway 61 bridge. Also, the temperatures recorded approximately two weeks earlier by the OWRC* were significantly higher than those observed on August 25th. Therefore, how did temperature and oxygen relate to the fish kill of the 25th when no such mortality had been observed prior to the 25th when conditions of temperature and oxygen were at least as adverse?

The obvious conclusion was to investigate further the matter of

* Water Quality Surveys Branch - 1970 Kaministikwia Survey - Appendix V

river flows and all waste discharges and to review in detail the results of samples collected at the time of this investigation. The subsequent sections deal with the investigations conducted into river flows and the summaries of waste inputs. This section presents the results of the samples collected on August 25th and 26th and compares these to the "background" water quality conditions.

As indicated, all results obtained during this investigation are presented in the attached Appendix. (See Appendix I to XI) For the purpose of drawing comparisons and for ease of interpretation, graphs have been presented of the Biochemical Oxygen Demand and the Chemical Oxygen Demand as a function of distance on the watercourse. (See Appendix I, Graphs (a), (b) and Appendix II, Graphs (a) and (b).) Similar graphs and comparisons could have been prepared for other parameters, however, the above should clearly illustrate the water quality conditions as noted during the investigation in relationship to the conditions which exist normally.

Stations 1, 2 and 3 - Mission River

The first observation relates to the water quality in the vicinity of the fish kill. On August 25, the concentrations of BOD_5 and COD in this area were significantly higher than the average concentrations noted from the results of approximately ten samples collected during the past two years. In the case of the BOD_5, the concentrations of 27 ppm were more than twice the recorded average value and exceeded by 30 percent the maximum concentration ever noted at this location.

COD concentrations, although higher than the average values recorded from the ten samples collected, did not exceed the maximum concentration ever noted. A perusal of the other parameters, particularly bacterial concentrations and phenols, presented essentially the same observations.

Station 7

The second significant observation is the apparent decrease in BOD_5 and COD concentrations at the confluence of the Mission and Kaministikwia Rivers. No clear explanation of this apparent reduction is presented, although it has been suggested that these concentrations reflect true values of the water quality conditions at this location whereas the Mission Stations reflected a build-up of waste materials at the river mouth. This would appear to be somewhat valid, particularly in view of the high BOD_5 concentrations.

Station 6 - Kaministikwia River

A station upstream on the Kaministikwia River, approximately one mile downstream from the Great Lakes Pulp and Paper Company Ltd. and opposite the Paterson elevators was sampled. The results obtained from this station clearly indicate that on August 25th both BOD_5 and COD concentrations were significant. The high values recorded, (in the range of the maximum concentrations noted during the past two years), suggest that either waste inputs from the discharge points upstream from the station increased significantly, or river flows changed prior to the investigation resulting in the reflected concentrations. Both aspects were reviewed further and are presented in subsequent sections of this report.

WASTE INPUTS

For the purpose of this investigation, a survey and identification of all discharges to the Kaministikwia and Mission Rivers was undertaken. This exercise was essential since it was felt that the pollutional effects of the waste inputs could have played a significant part in this fish kill. The intent here is to indicate in some concrete manner the degree of utilization of the watercourses as effluent receivers.

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Since the fish kill was observed near the mouth of the Mission River, all waste inputs to the Kaministikwia River upstream from its confluence with the Mission River and any waste discharges to the Mission channel were considered in the review.

It should be pointed out as well that on August 25, 1970, the Regional Office Staff attempted to determine if there were any unusual discharges to the watercourse that could be related to the observed fish mortality. No detrimental spills or unusual discharges were subsequently noted or reported. The observations made at that time are included in the section on Water Quality and the information obtained is presented in Appendices I to IV.

The utilization of the Kaministikwia River for a waste receiver has been recognized for many years. Industrial and domestic wastes alike enter the river through many outfalls situated along the banks of the river within a reach of approximately 6 miles extending from the mouth of the river to approximately the new Highway 61 bridge. An itemized list of the outfalls identified to date is presented in Appendices VII and VIII.

(a) DOMESTIC WASTE INPUTS

The domestic waste outfalls have been segregated into two classes: those discharging to the Kaministikwia River upstream from the Mission confluence and those discharging to the Kaministikwia River downstream from the Mission confluence, but above the McKellar. It should be noted that other municipal outfalls exist below the McKellar channel, however, it is felt that these discharges could play a part in the total degradation of the Mission Branch only under the severest of circumstances. On the other hand, the subsequent section "Characteristics of River Flows" indicates how the downstream

outfalls discharging to the river between the Mission and the McKellar channels could have contributed a pollutional, oxygen depleting effect on the Mission River. Therefore, these have been included in this review.

At the time of the fish kill, domestic wastes from five known municipal outfalls were contributing untreated domestic-type sewage to the Kaministikwia River upstream from the mouth of the Mission River. In the vicinity of the Mission River confluence, there are five additional outfalls which, depending upon flow variations in the river, could also contribute wastes to the Mission River. In this regard, it has been conservatively estimated that the combined waste flow in terms of BOD_5 from the ten outfalls would be equivalent to a population of approximately 20,000 to 25,000 persons. This estimate takes into account the "population equivalents" contributed by non-domestic sources which also discharge to the municipal sewer system. In that the collector system, tributary to these outfalls, is comprised wholly of combined sewers, the influence of storm run-off could elevate the 20,000 to 25,000 population equivalent figure by a considerable margin.

UPSTREAM OUTFALLS

Two of the five upstream outfalls contribute relatively large quantities of untreated domestic wastes to the Kaministikwia River. These are the Tarbutt Street and Stanley Street outfalls. Both have an adverse effect on the watercourse immediately downstream from the point of discharge. In the case of the Stanley Street outfall, the direct effect is not immediately apparent in view of its proximity to the Great Lakes Paper Company outfall, however, the total impairment in this reach must take into account the contribution from this source. This is particularly evident in view of the probability that all wastes from the Canadian Car Division's plant likely discharge to the river through this outfall.

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The remaining three upstream domestic outfalls are as significant as the Stanley and Tarbutt outfalls, however, their measureable effects on the river are not noticeable because of the overshadowing effect of all other upstream discharges to the river.

Downstream Outfalls

The downstream outfalls which also contributed to the total impairment of the Mission River at the time of the fish kill are the Christina, Empire, New Vickers, Duncan and Ridgeway Ave. outfalls. Owing to the fact that the lower reach of the Kaministikwia River reverses flow, on occasion, and discharges to the lake via the Mission Channel (see subsequent section) these five outfalls have been included in this review.

Of significance, relative to the wastes carried by these outfalls, is the concentrations of petroleum-like substances which are discharged. Petroleum wastes, i.e. oils, gasolines, etc., can have a very adverse effect upon the entire ecological river system and under no circumstances should these be allowed to enter a watercourse. The origin of this type of waste is mainly from the CPR yards adjacent to the railway station, however, periodic contributions from local gasoline stations cannot be ruled out.

(b) INDUSTRIAL WASTE INPUTS

In this category, significant quantities of wastes are being directly discharged to the Kaministikwia River. In this regard, it is estimated that approximately 65 million gallons of treated and untreated industrial wastes are being discharged daily to the River between the McKellar confluence and the new Highway 61 bridge. Following through with the concept of "population equivalents", it is noted that the discharges from these sources, based on BOD_5, represents an equivalent population of approximately 2.1 million persons. A list of the

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industries discharging to the watercourse, together with relevant information pertaining to waste characteristics is presented in Appendix VII, Table (b).

It should be obvious that the total impairment of the Kaministikwia River is due largely to the industrial waste discharges. In this regard, the Great Lakes Paper Company discharges by far the greatest contribution. Great Lakes discharges indicate that the waste flow fluctuates from 50 MGD to 70 MGD. For the purposes of this report, we have utilized information supplied by the Company which suggests approximately 60 MGD waste flow. It is felt that the actual figure is not entirely relevant to this review in that the flow appears to be well over 50 MIGD regardless of what information is used.

In considering other industries, Industrial Grain Products discharges approximately 300,000 GPD of a very high strength waste. In population equivalents therefore, this Company alone discharges daily a BOD_5 contribution to the watercourse equivalent to a city of 150,000 persons. This illustrates that the quantity of flow is not necessarily a true indication of the waste input.

The presence of petroleum-like substances in the watercourse has been mentioned in the preceding section. It should be noted here that diesel fuel discharges occur to the river via CPR outfalls as well as the municipal outfalls. On several occasions, particularly evident when observed from the air, a number of relatively large "oil slicks" have been noted adjacent to the CPR outfalls. As indicated earlier, these wastes are most harmful and under no circumstances should they be permitted to enter a watercourse at any time.

On the date of the investigation it was reported by the plant manager and Company personnel that the Abitibi (Mission) pulp Company was shut down prior to and during this investigation. As such, minimal waste discharge was being effected from this mill and therefore little water quality impairment

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could be attributed to their discharge.

CHARACTERISTICS OF RIVER FLOWS

The flow characteristics of the Kaministikwia River and its tributaries the McKellar and the Mission, have been known to play a large part in the total ability of the watercourse to accept waste discharges.

In that these characteristics appeared to be significant on the date of the investigation, it was subsequently felt that the matter of river flows prior to August 25th required a more thorough review. Information in this regard was therefore obtained from the Ontario Hydro relative to their operations at the following locations:

(a) Dog Lake
(b) Shebandowan Lake
(c) Silver Falls Generating Station
(d) Kakabeka Falls Generating Station
(e) Thunder Bay (Steam) Generating Station

Shebandowan and Dog Lakes are utilized as water storage reservoirs. During periods of high run-off from each watershed, water is stored in these natural impoundment areas. By the manipulation of control structures at the outlets of each lake, the stored water is subsequently released as required down the Shebandowan and Kaministikwia Rivers during periods of low run-off to feed the downstream generating stations. Hydro also attempts to maintain sufficient flows in the rivers to accommodate the tourist industry at Kakabeka Falls and to provide dilution for the waste discharges to the lower Kaministikwia River. In this regard, Ontario Hydro attempts to maintain a river flow of no less than 300 c.f.s. on weekends and 150 c.f.s. during week days to satisfy the above indicated flow requirements.

This summer the Kakabeka Falls Generating Station was completely shut down for maintenance. This lack of generation, plus the ever increasing demand for electrical energy within the Region, prompted Hydro to utilize the

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steam generating plant located in Thunder Bay on the Mission Island on a continual basis. On occasion this year, the steam generating station was called upon to provide power equivalent to approximately three-quarters of its total capacity. It is beyond the scope of this report to review the operation of power generation, however, it is important to note the resulting water utilization in conjunction with this generation. Steam plants require water for cooling purposes. In this regard, the Thunder Bay plant can consume approximately 104,000 U.S. GPM or 230 CFS. Water is obtained from the Mission Channel with the "spent water" discharged to Lake Superior.

All water discharged from Dog Lake passes through the Silver Falls Generating Station. One week prior to August 25, the average flow measured in the Kaministikwia River at this station by Hydro was approximately 354 CFS. Similarly, the average flow recorded in the river at the Kakabeka Falls Generating Station for the same period was 390 CFS. (See Appendix IX).

The above observations suggest therefore that immediately prior to the fish kill, a relatively good flow of water was being maintained in the river. This flow can be considered as representative of the flow which proceeds down the river to Lake Superior. If only the lower reach of the river system is considered, i.e. between the new Highway 61 bridge and the mouth, it is assumed that, on the average, 390 CFS of flow was available for waste dilution. Based on the information available concerning volumes of waste discharges from all sources between the Highway bridge and the confluence with the Mission tributary, it would appear that a dilution factor of approximately 1:2.2 would be available. This represents relatively poor dilution and is discussed further in a subsequent section of this report.

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The flow characteristics of the river system from the Highway 61 bridge to the mouths of the rivers were examined more closely. Particular emphasis was placed upon directions of flow.

If it is assumed that all water entering the river system upstream from the Great Lakes property (i.e. 390 CFS) also leaves the system and discharges to Lake Superior via one or more of the outlets, then the river flows recorded at Kakabeka Falls can be related to the water consumption of the Thunder Bay Steam Generating Plant. If the flow entering the system exceeds the generating station consumption then it is logical to assume that the Kaministikwia flow splits in some proportion at the Mission confluence. On the other hand, if the flow entering is less than the generating station water consumption, then it is likely that the entire river flow is drawn down the Mission channel. This would suggest that the lower Kaministikwia flow would approach zero or, because of a "suctioning effect", may reverse direction and also contribute to the Mission Channel flow.

It has been determined that during August 24th and 25th, the steam plant consumption was in the order of 230 CFS. Further, the Abitibi (Mission) Plant was only drawing a minimal amount of water from the Mission River due to Mill shutdown. In this regard, a low consumption of approximately 10 CFS has been assumed for this mill. The combined demand, therefore, was approximately 240 CFS.

During the investigations on August 25th, it was noted that the Mission Channel flow upstream and downstream from the Hydro intake was easterly toward Lake Superior. This suggests that on that day the water consumption demands of both the steam plant and the pulp mill were more than adequately being satisfied; that is, more than 240 CFS was being directed down the

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Mission Channel. Since the average flow in the Kaministikwia River during the week prior to this investigation was recorded at 390 CFS, it would appear that the flow was splitting at the Kaministikwia-Mission confluence; but in favour of the Mission River, (i.e. - say 250 CFS down Mission to 140 CFS down Kaministikwia).

A closer review of the flow records just prior to this investigation also reveals that the flows vary significantly day by day. For example; on August 22nd the flow recorded at the Silver Falls Generating Station was 406 CFS and on August 23rd the flow recorded at the Kakabeka Falls Generating Station was 588 CFS. These flows suggest that more than average flow conditions existed two to three days prior to the date of the investigations. Therefore, it is suggested that ample flow was available at that time to meet the hydraulic demand of the Mission tributary and create a possible downstream flow in the lower Kaministikwia River as well.

On August 23rd, on the other hand, the flow recorded at the Silver Falls Generating Station was only 245 CFS and on August 24th the flow at Kakabeka was only 332 CFS. This represents a flow reduction at the two stations within one day of approximately 40 and 44 percents, respectively. Further, the river flow reduced to the point where it was relatively within the same range as the Mission demand. Since the water demand, or consumption of the steam plant and the paper mill remain relatively constant, it is entirely feasible to assume that on occasion and for short periods, the demand exceeded the supply. If this happened, and it appears likely in this instance, the Mission demand (i.e. the steam plant - pulp mill consumptions) would likely be met by the flow into the system at Kakabeka, the reverse Kaministikwia River flow and a flow from Lake Superior. This latter contribution is significant in that this flow is

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probably responsible for "drawing" fish from the lake into the vicinity of the mouth of the Mission River.

RIVER QUALITY

The water quality, particularly in the lower reaches of the Kaministikwia River, was reviewed for the purposes of this investigation. It is not the intent, or objective of this report to completely cover this subject except by brief reference to the quality in relationship to the August fish kill. Two weeks prior to this investigation, the Water Quality Surveys Branch, Ontario Water Resources Commission, undertook a complete survey of the river and therefore the subsequent report now being prepared will cover this aspect in detail.

It has been suggested that the river water quality is such that it is not capable of supporting a fish population. If this is true, then the only way in which fish could become subjected to the toxic effects of the river would be for the water quality to improve sufficiently for fish to be attracted into the watercourse. Once inside the confines of the river, fish would then become vulnerable to waste discharges and the effects which these create. Sufficient data relative to the actual fish populations in the river, particularly in the lower reach, is not available to comment further on this point, however, it is a subject which could be further investigated.

There are several inter-relating factors which have been observed to significantly affect the present water quality in the watercourse. These are as follows:

(a) Flow Characteristics
(b) Waste Inputs
(c) Topography
(d) Lake vs. River Temperature

The first two factors are covered in earlier sections within this report. Both are significant parameters to consider and should be taken into

account whenever the question of water quality is being considered. The inter-relationship in this regard was observed at the time of this investigation. Visually, the river appeared to be receiving a much higher than normal waste load. Severe colour deterioration and large quantities of bark-like debris were noted. The results of tests conducted on August 25 and the sample results which were ultimately received subsequent to the investigation appeared to support these observations. However, it must be recognized that increased concentrations of substances within the watercourse could reflect an increase in the waste load and/or a decrease in the water flow. A change in either, or both, of these factors could bring about the indicated change in water quality.

The third factor, topography, also plays an important role. The lower reach of the watercourse from the turning basin to the mouth, including the Mission Channel, is constantly being dredged. As a result, the river bottom is lowered and the gradient is flattened. Further, owing to the increased width of the river in this reach, the velocity of flow is considerably reduced. The net effect of these features is to produce a watercourse which is not unlike an estuary. In this regard, flow reversals have been observed on several occasions. This would suggest that waste substances discharged to the watercourse in all likelihood tend to settle in the lower river reach. The locations of deposition in this regard and the concentrations would vary from season to season, owing to other related factors.

Of significance as well, is the relationship between the lake and river temperatures. On several occasions in the past a distinct temperature interface has been observed in the zone where river water mixes with the lake water. This relationship is not uncommon when two bodies of water of different temperatures meet. However, in the observed situations on the Kaministikwia

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River and its tributaries, the temperature interface translocates up and down river depending upon the flow patterns.

It is also distinguished by a relatively clear-water region downstream from the interface and an impaired-water region upstream. The mechanics of this temperature relationship have not been fully investigated, although further studies in this regard would appear warranted. The suggestions relative to this aspect is that poor mixing of river and lake water is effected. Also, the build-up of waste materials on the upstream side is possible, which could result in a further river degradation in this vicinity than anticipated. The fact that the interface is capable of translocation from one zone of the river to another suggests that the build-up of contaminants, particularly those held in suspension, also translocates. The possibility exists therefore, that the translocation of waste materials in combination with the other factors mentioned, could contribute significantly to an unhealthy environment within the watercourse. The occurrence, therefore, of dead fish at certain defined locations within the watercourse should not be totally unexpected, and until improvements are achieved relative to waste inputs, the undertaking of exhaustive investigations to define causes would be questionable.

OBSERVATIONS AND CONCLUSIONS

The investigations conducted subsequent to the occurrence of the fish kill in August 1970, revealed certain aspects of importance relative to the Kaministikwia River Watershed. The kill itself represents the effect; the cause, however, was difficult to determine in this instance owing to the existence of a number of related factors, most of which have been presented in this report.

At the time of the kill, an unusually high concentration of organic and chemical substances appeared to be present in the waters in the area of the

dead fish. Further the lack of oxygen in the river at the time of the investigation leaves little doubt as to why fish succumb. The number of fish affected was relatively small and as such, the kill has been classified as "moderate" in accordance with the classification scheme accepted by the Ontario Water Resources Commission. The two species of fish were not significant since these were of the poorer game, or non-edible variety.

The chemical and bacteriological characteristics of the water noted at the time of the investigation on August 25th revealed that the quality had deteriorated from the "norm" and in fact, had undergone this change commencing only a few days prior to this investigation. A review of laboratory analyses recorded daily by the Ontario Hydro Thunder Bay Steam Plant chemists as a result of their raw-water testing procedures, substantiates this observation. Further, the Commission's Water Quality Surveys Branch conducted a thorough survey of the Kaministikwia River and its tributaries during the week of August 10, 1970. Indications are that this earlier survey revealed a water of better quality than that observed during the investigation on August 25.

On the basis of these conclusions, attempts were made to determine the possible cause(s) of this apparent quality change. In that the observations of past investigations did not appear to satisfactorily answer all the questions relative to this kill, it appeared that a more thorough review was required. In this regard, the flow characteristic of the river appear to be quite significant. It would appear that this aspect requires considerably more review since the entire question of waste assimilation and waste quantities may hinge upon this factor. Further, there are indications that the physical character of the river itself plays a very important role in waste or effluent assimilation.

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In conclusion, the Kaministikwia River and tributaries are severely impaired as a result of domestic and industrial waste discharges. As such, the occurrence of fish kills should not be totally unexpected. It would be reasonable at this time to expect a restoration of this watercourse to a purely natural state in view of the present day uses. However, further studies may be warranted to define more accurately all these factors, which may govern as well the assimilation of waste discharges, or treated waste effluents.

It is noted in the section on "River Quality" that a higher than normal waste concentration was present in the Mission River on August 25th in the area of the fish kill. Further, the flow characteristics of the river suggests that prior to the fish kill investigation of August 25, 1970, all wastes discharged to the Kaministikwia River between the Highway 61 bridge and the McKellar channel could have been drawn down the Mission Branch. It has already been stated that dilution was minimal, waste concentrations were abnormally high and in all likelihood, fish were being attracted to the mouth by a reversal in river flow sometime during August 24th. The fish mortality observed on August 25th therefore resulted.

Finally, the Commission's "Guidelines and Criteria for Water Quality Management in Ontario" indicates that water should be protected for the greater number of uses, present and future. In this regard, and where multiple use is evident, conflicting uses often appear. On the basis of the established, identified guidelines and criteria, the Ontario Water Resources Commission can adopt specific standards for a water course. As indicated previously, a River Basin Study was conducted during August, 1970 by the Ontario Water Resources Commission. In this regard, proposals and recommendations relative to this long range aspect of Water Management for the Kaministikwia River are currently

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being reviewed. It would, therefore, be premature at this time to comment further on this aspect until the Commission releases more information. The need to adopt standards for the Kaministikwia River, however, appears evident and it is therefore recommended that water quality standards be drafted as soon as possible. These standards, when adopted, will prove invaluable for present and future discussions relating to all pollution abatement programs, watershed uses and treatment requirements.

RECOMMENDATIONS

With respect to this investigation, the following recommendations are submitted:

(1) Based upon the results of surveys and basin studies which have been conducted by staff to date, water quality standards commensurate with anticipated utilization of the Kaministikwia River Basin should be drafted as soon as possible.

(2) Additional investigations should be undertaken by the OWRC to further define some of the other pertinent factors which appear to influence the characteristics of the watercourse relative to waste assimilation.

(3) Of immediate concern at this time is the matter of maintaining a suitable river flow throughout the year. In this regard, it is suggested that the Ontario Hydro be requested by the Commission to maintain a minimum flow during the dry summer months of 600 CFS. It is understood that further refinements to this minimum flow could periodically be made as information relative to the watercourse is disseminated.

(4) Arrangements should be made for the routine monitoring of all significant waste inputs to the watercourse. An inventory of these sources should then be drafted and records of all pertinent information relative to the

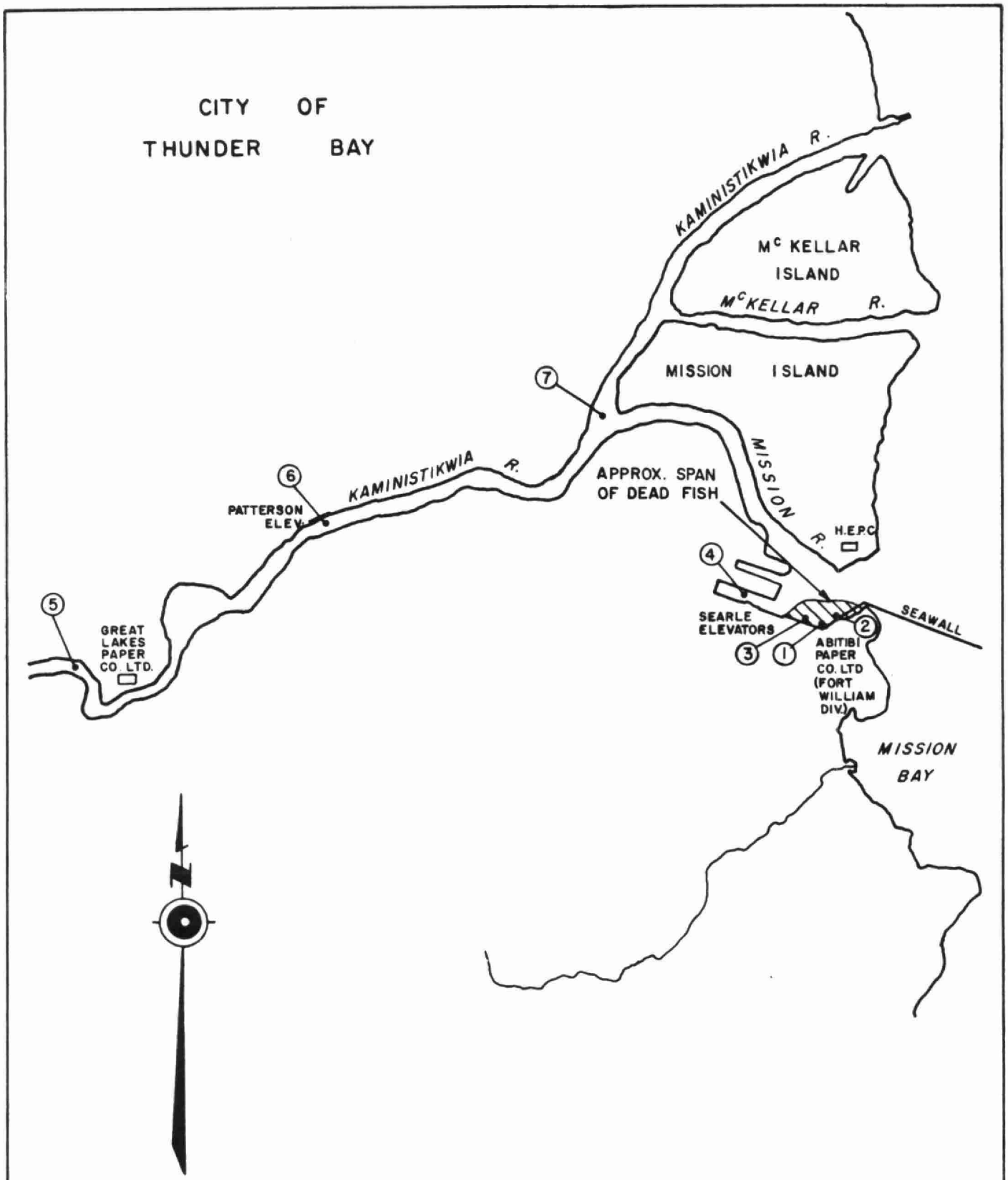
..... 24

waste characteristics made available to the public. The published report could also include the schedules of all adopted pollution abatement programs now being implemented.

Prepared by: .....

J. R. Marsh, P. Eng.
District Engineer
Division of Sanitary Engineering

JRM:pb



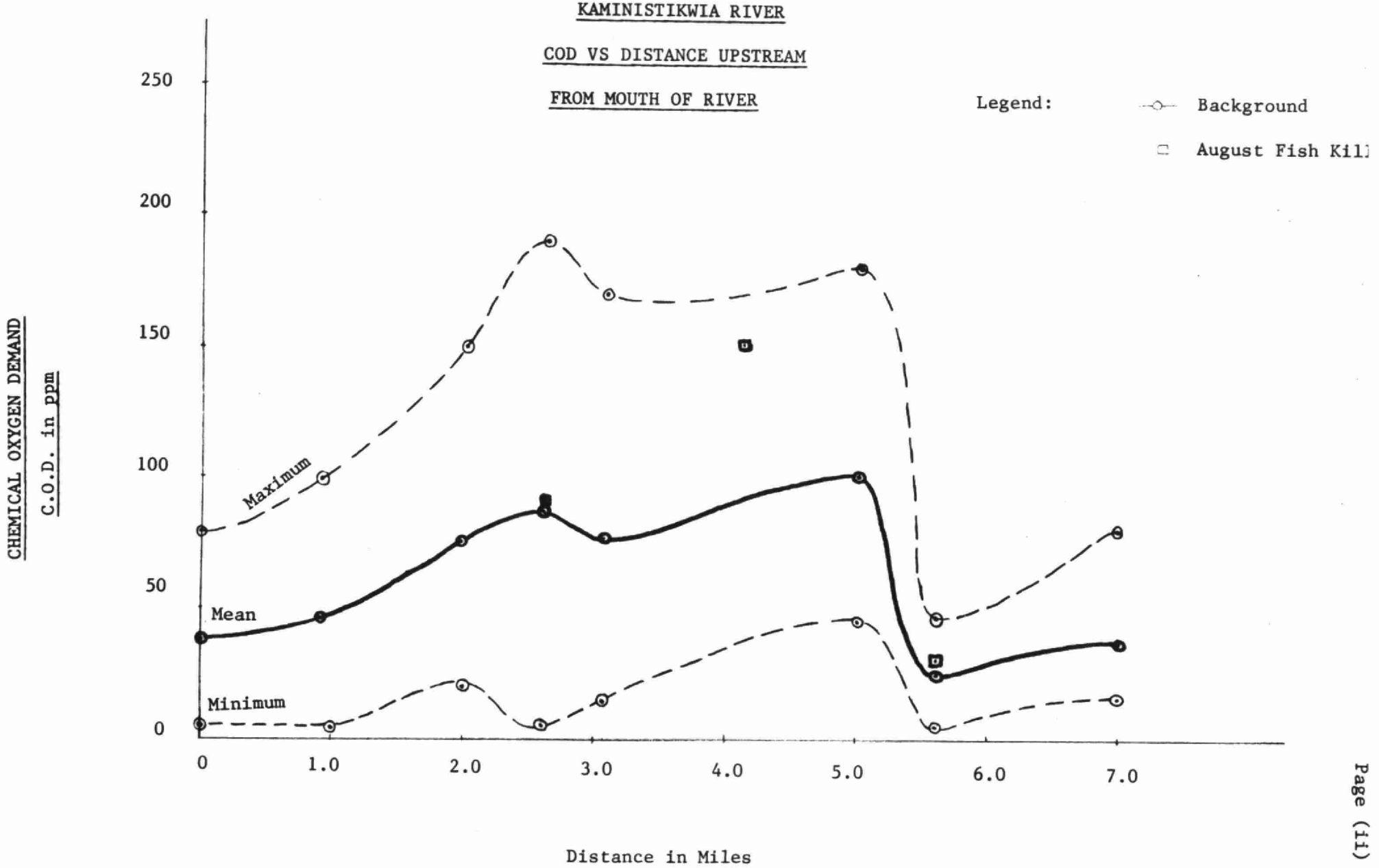
FISH KILL INVESTIGATION AUG. 25, 1970

LOCATION PLAN AND SAMPLING POINTS

KAMINISTIKWIA RIVER

COD VS DISTANCE UPSTREAM

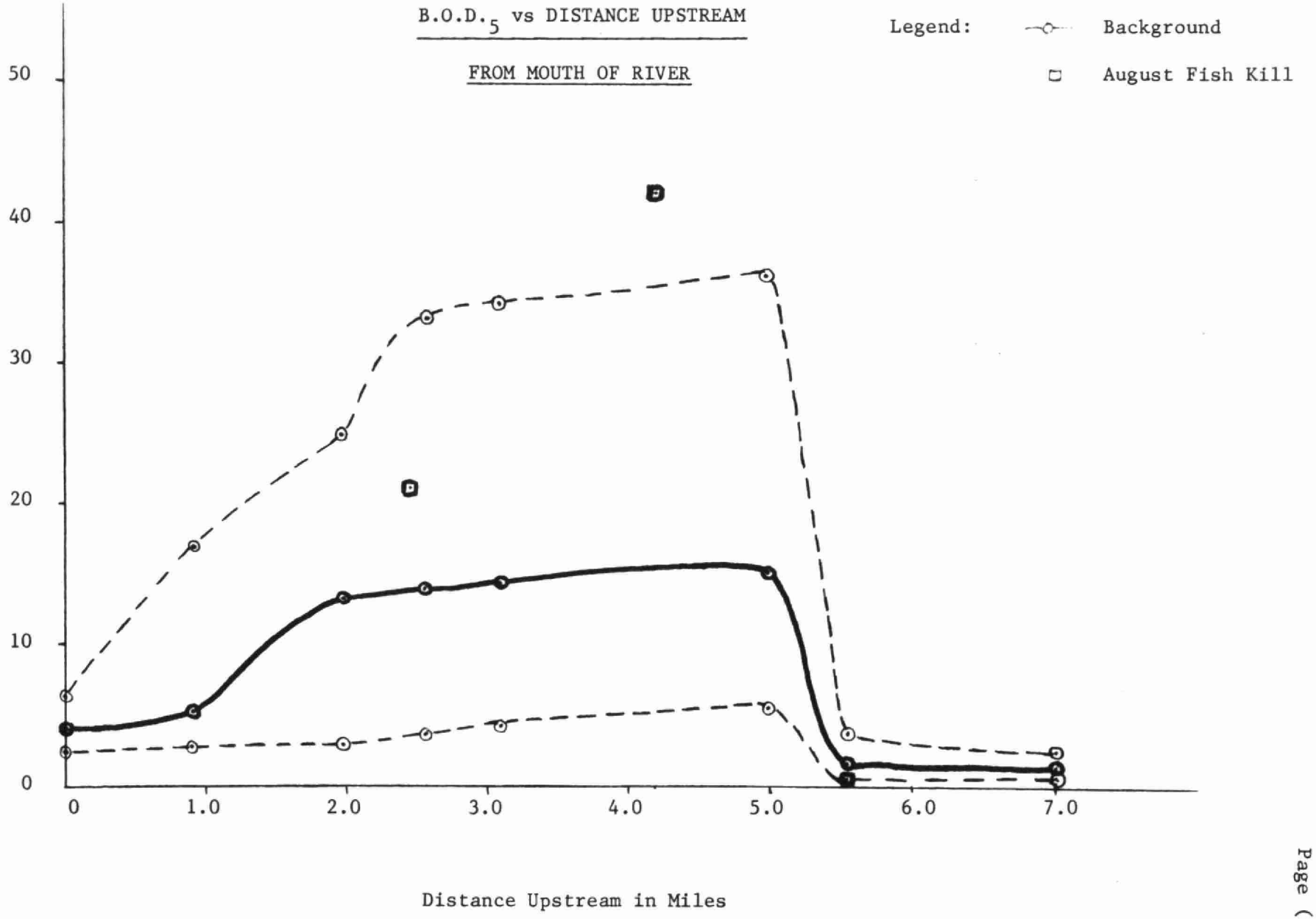
FROM MOUTH OF RIVER



KAMINISTIKWIA RIVER

B.O.D.$_5$ vs DISTANCE UPSTREAM

FROM MOUTH OF RIVER



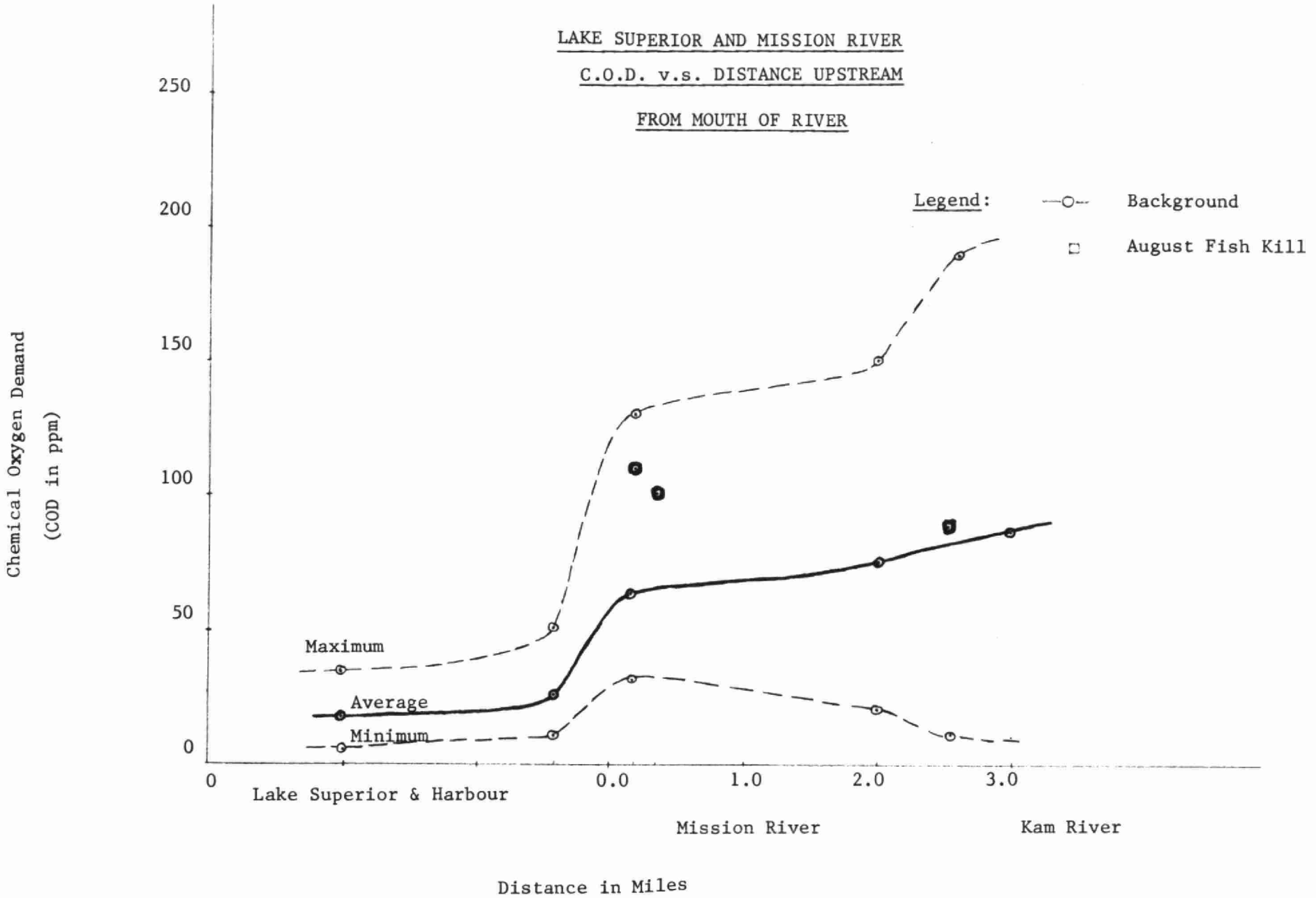
APPENDIX I - TABLE (a) (b)

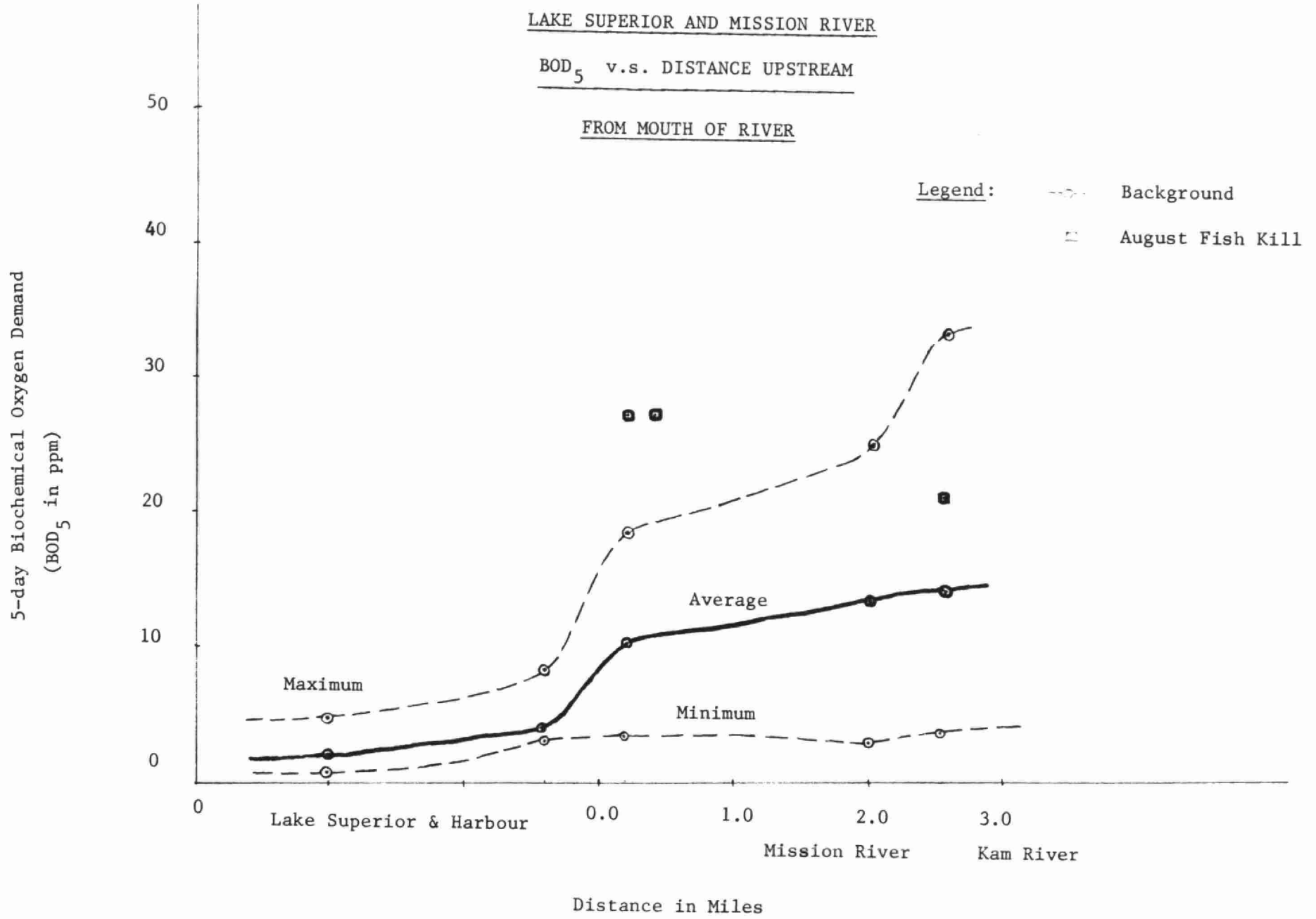
KAMINISTIKWIA RIVER

Data	Location *	K0.0	K0.9	K2.0	K2.5	K3.1	K5.0	K5.5	K7.0
B. O. D.	Maximum	6.3	17.0	25.0	33.0	34.0	36.0	3.8	2.5
	Mean	4.1	6.4	13.2	14.0	14.1	15.1	1.8	1.2
	Minimum	2.5	2.7	3.0	3.8	4.2	5.6	0.6	0.7
C. O. D.	Maximum	80	100	150	190	170	180	47	80
	Mean	39	47	75	87	76	100	25	37
	Minimum	10	10	20	10	16	45	10	16

* Distance in miles upstream from Kaministikwia River mouth.

Note: Data based on results of all samples collected from river for 1968, 1969 and 1970 (W.Q.S.M. Program - approximately 10 samples each location). All results expressed in parts per million (ppm).


LAKE SUPERIOR AND MISSION RIVER
C.O.D. v.s. DISTANCE UPSTREAM
FROM MOUTH OF RIVER
Legend:
Background
August Fish Kill
Chemical Oxygen Demand
(COD in ppm)
250
200
150
100
50
0
Maximum
Average
Minimum
0
Lake Superior & Harbour
0.0
1.0
2.0
3.0
Mission River
Kam River
Distance in Miles


LAKE SUPERIOR AND MISSION RIVER
BOD5 v.s. DISTANCE UPSTREAM
FROM MOUTH OF RIVER
Legend:
Background
August Fish Kill
5-day Biochemical Oxygen Demand
(BOD5 in ppm)
50
40
30
20
10
0
Average
Maximum
Minimum
0
Lake Superior & Harbour
0.0
1.0
2.0
3.0
Mission River
Kam River
Distance in Miles

APPENDIX II - TABLE (a) (b)

LAKE SUPERIOR AND MISSION RIVER

Data \ Location*		L.S. - 2.0	L.S. - 0.40	KM. - 0.2	KM. - 2.0	K. - 2.5
B. O. D.	Maximum	4.9	5.7	18	25	33
	Mean	2.1	4.2	10.3	13.2	14.0
	Minimum	0.8	3.0	3.2	3.0	3.8
C. O. D.	Maximum	35	50	130	150	190
	Mean	17.7	26.0	63.2	75	86.7
	Minimum	4	10	31	20	10

* Distance upstream in miles from Mission River mouth.

Note: Data based on results of all samples collected from river for 1968, 1969 and 1970 (W.Q.M. Program - approximately 10 samples each location). All results expressed in parts per million (ppm).

A P P E N D I X III - Table (a)

FISH KILL REPORT - AUGUST 25, 1970 - ANALYTICAL RESULTS (OWRC)

Sample Location and Station Number	Date Obtained	Time	D.O. ppm	Temp. °C	Coliforms F.C.	Coliforms T.C.	BOD5 ppm	COD ppm	pH	Phenols ppb	Colour Units
Southwest corner of Abitibi Mission Mill Seawall at water intake - (1)	Aug.25/70	3:20 pm	-	-	-	-	22	90	6.3	12	35
Southwest corner of Abitibi Mission Mill Seawall-150 ft. north - (2)	Aug.25/70 Aug.26/70	3:25 pm 10:35 pm	0.4 1.6	18 18	500 1,140	12,000 1,730	27 11	110 70	6.4 6.8	17 17	35 25
Southwest corner of Abitibi Mission Mill Seawall-800 ft. west - (3)	Aug.25/70 Aug.26/70	4:15 pm 10:50 am	0.4 1.4	18 18	5,000 890	15,000 2,700	27 12	100 40	6.4 6.8	17 17	35 20
Midpoint of Searle Elevator Slip - (4)	Aug.25/70	4:35 pm	0.1	18	1,590	14,000	20	80	6.5	13	35
Kaministikwia R. above Great Lakes Paper Outfalls - (5)	Aug.25/70	5:40 pm	7.9	21	210	1,340	1.1	30	6.8	1	40
Kaministikwia R. at Patterson Elevators - (6)	Aug.25/70	5:50 pm	0.0	20.1	500	6,900	42	150	6.6	7	70
Kaministikwia R. at Mission R. confluence - (7)	Aug.25/70	6:00 pm	0.0	18.3	1,500	19,000	21	80	6.7	18	50

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

All analyses except pH reported in p.p.m. unless otherwise indicated

RIVER SURVEY

1 p.p.m. = 1 mgm. / litre
= 1 lb./100,000 Imp. Gals.

Municipality: Thunder Bay

Report to: J. R. Marsh, District Engineer
Division of Sanitary Engineering
Thunder Bay Regional Office

c.c.

Watercourse: Fish Kill-Thunder Bay and Tributaries

Date Sampled: Aug.25/70 by: B.F. Mason and W.J. Grobelny

Lab. No.	Sample Point No.	5-Day B.O.D.	C.O.D.	pH	Phenols	Colour Units	BACTERIOLOGICAL EXAMINATION Lab. No.	Faecal Coliforms	Coliform Bacteria
R1607		22	90	6.3	12	35			
R1608		27	110	6.4	17	35	1 2257	500	12000
R1609		27	100	6.4	17	35	1 2258	5000	15000
R1610		20	80	6.5	13	35	1 2259	1590	14000
R1611		1.1	30	6.8	1	40	1 2260	210	1340
R1612		42	150	6.6	7	70	1 2261	500	6900
R1613		21	80	6.7	18	50	1 2262	1500	19000

R1607	1	South west corner of Abitibi Mission Mill Seawall at water intake - grab at 3:20 p.m.
R1608	2	South west corner of Abitibi Mission Mill Seawall - 150' north - grab at 3:25 p.m.
R1609	3	South west corner of Abitibi Mission Mill Seawall - 800' west - grab at 4:15 p.m.
R1610	4	Midpoint of Searle Elevator Slip - grab at 4:35 p.m.
R1611	5	Kaministikwia River above Great Lakes Paper outfalls - grab at 5:40 p.m.
R1612	6	Kaministikwia River at Patterson Elevators - grab at 5:50 p.m.
R1613	7	Kaministikwia River at Mission River confluence - grab at 6:00 p.m.

60-18863

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

APPENDIX III - Report (b)

All analyses except pH reported in p.p.m. unless otherwise indicated

RIVER SURVEY

1 p.p.m. = 1 mgm. / litre
= 1 lb./100,000 Imp. Gals.

Municipality: Thunder Bay

Report to: J.R. Marsh, District Engineer
Division of Sanitary Engineering
Thunder Bay Regional Office

c.c.

Watercourse: Fish Kill-Thunder Bay Tributaries

Date Sampled: Aug.26/70 by: B. Mason and W.J. Grobelny

Lab. No.	Sample Point No.	5-Day B.O.D.	C.O.D.	pH	Phenols	Colour Units	BACTERIOLOGICAL EXAMINATION Lab. No.	Faecal Coliforms	Coliform Bacteria	
R1614		11	70	6.8	17	25	1 2273	1140	1730	
R1615		12	40	6.8	17	20	1 2274	890	2700	

R1614	2A	South west corner of Abitibi Mission Mill Seawall - 150' north - grab at 10:35 a.m.
R1615	3a	South west corner of Abitibi Mission Mill Seawall - 800' west - grab at 10:50 a.m.

60-18863

APPENDIX IV - TABLE (a)

MISSION RIVER WATER QUALITY (HYDRO)

THUNDER BAY GENERATING STATION - AUGUST, 1970 - RAW WATER

Date	pH	°K	M Alk.	Hardness			SiO2	°Cent. Temp.	DO_2	NaCl	O.A.	Col.
				Tot.	Ca.	Mg.						
Aug. 4	7.35	110	41.0	48.8	27.2	21.6	-	-	-	-	-	-
10	7.10	120	39.0	45.2	30.0	15.2	3.70	-	-	3.70	-	100
11	6.95	120	38.6	48.8	24.8	24.0	3.80	18.0	2.20	-	19.2	85
12	7.10	135	39.8	49.6	28.0	21.6	4.30	18.0	2.10	-	-	85
13	7.20	125	40.8	50.0	30.8	19.2	4.10	-	-	-	-	85
14	7.05	122	40.4	49.2	30.0	19.2	3.60	-	-	10.0	-	85
17	7.22	132	38.8	52.0	30.0	22.0	3.60	-	-	10.8	17.6	70
18	7.20	135	42.0	51.2	28.0	23.2	3.90	18.0	1.5	-	17.6	70
19	7.25	135	41.0	50.8	29.2	21.6	3.30	17.0	3.0	-	18.4	70
20	7.10	158	44.2	60.4	36.0	24.4	4.10	-	-	-	-	85
21	7.20	160	44.0	60.8	34.8	26.0	3.40	-	-	18.4	-	85
24	6.95	180	45.8	67.2	38.0	29.2	4.30	18.0	0.0	26.4	39.2	125
25	7.00	178	44.8	66.0	36.8	29.2	3.80	17.0	Trace	-	35.2	100
26	7.00	160	44.6	62.0	37.2	25.8	3.60	17.0	0.0	-	32.0	85
27	7.00	170	47.0	66.0	39.2	26.8	4.30	18.0	Trace	-	31.2	100
28	6.85	180	46.4	68.4	40.8	27.6	4.10	-	-	24.4	-	100
31	6.78	198	45.2	70.8	44.0	26.8	5.20	18.0	0.0	24.4	35.2	150

APPENDIX V - TABLE (a)

WATER QUALITY SURVEYS DATA - AUGUST 11-14, 1970 (OWRC)

ASSUMED ELEVATION - 600 FT. ASL

Source	Depth	Temp. °C	D.O.-%Sat.	D.O.-ppm
Mouth of Mission R. Abitibi - HEPC	Surface	23	20	1.7
	5'	21	25	2.0
	10'	20	40	3.5
Mission & Kam R.	1'	24	30-40	2.5
	5'	-	30-40	
	10'	21	5-6	0.4
	Bottom	21	0	0.0
Patterson Elevators	1'	25	50	4.0
	10'	19	5	0.45
Turning Basin Kam R.	Surface	25	70	5.7
	15'	20	30	0.89
Great Lakes Paper Intake	All	23	85	7.2

ONTARIO WATER RESOURCES COMMISSION
CHEMICAL LABORATORIES

All analyses except pH reported in p.p.m. unless otherwise indicated

RIVER SURVEY

1 p.p.m. = 1 mgm. / litre
= 1 lb. / 100,000 Imp. Gals.

Municipality: Twp. of Forbes

Report to: J.R. Marsh, Thunder Bay Regional Office.

c.c. W.Q. Surveys
Central Files

Watercourse: Kaministikwia River

cc S. . MacBeth
S. Harangozo
D. Dyck, 311 Culyer Street, Thunder Bay, Ont.

Date Sampled: Aug. 20.70 by: D.D.

mm

Lab. No.	Sample Point No.	5-Day B.O.D.	Solids			Turbidity Units	NITROGEN AS N				Conductivity in Micromhos per cm³
			Total	Susp.	Diss.		Total Kjeldahl	Free Ammonia	Nitrite	Nitrate	
R35-155		1.2	80	5	75	1.5	.32	0.01	0.010	0.03	65

Lab. No.	Sample Point No.	PHOSPHORUS AS P Tot.	PHOSPHORUS AS P Sol.	Chloride as Cl	Phenols in ppb	C.O.D.	pH at Lab
R35-155	.10	0.096	2	0	30	7.8	

Lab. No.	Sample Point No.	
R35-155	C1	Kaministikwia River 5 Miles North of Hwy 17 on Silver Falls Road

5M 60-31785

APPENDIX VII - TABLE (a)

OUTFALLS TO KAMINISTIKWIA RIVER

BETWEEN NEW HIGHWAY 61 BRIDGE AND MC KELLAR TRIBUTARY

MUNICIPAL

1. Ridgeway Avenue - Storm overflows from Sanitary System and diesel fuel
2. Duncan Street - Raw domestic wastes
3. New Vickers Street - Raw domestic wastes
4. Empire Street - Raw domestic wastes
5. Christina Street - Raw domestic wastes
6. Tarbutt Street - Raw domestic wastes
7. Queen Street - Raw domestic wastes
8. James Street - Raw domestic wastes
9. Bailey Avenue - Raw domestic wastes
10. Stanley Avenue - Raw domestic wastes

INDUSTRIAL

1. The Great Lakes Paper Company, Limited

    (a) Kraft woodroom plus 2/3 news woodroom
    (b) Chipper Plant
    (c) Diffuser - Kraft mill combined sewer
    (d) Groundwood screenroom, sulphite screen room and 1/3 newsmill woodroom
    (e) Filter plant
    (f) Sulphite sewer
    (g) (Part of (d))
    (h) Wet end paper machines
    (i) Wet end paper machines
    (j) Steam plant
    (k) Shops, dry end paper machines
    (l) Office

2. Dow Chemical of Canada, Limited

3. Industrial Grain Products, Limited

4. Canadian Pacific Railway

    (a) Outgoing engine and rip track

APPENDIX VII - TABLE (b)

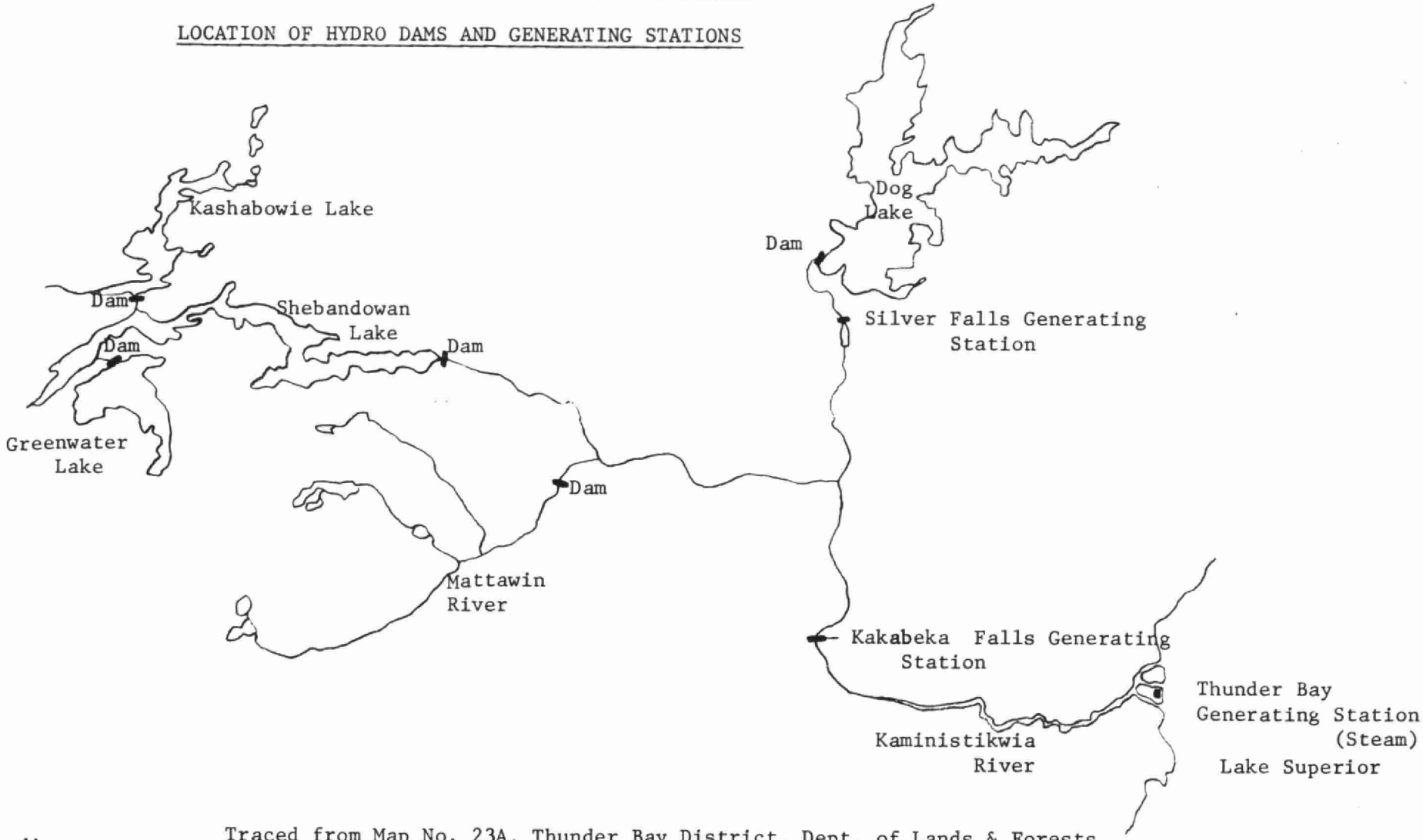
INDUSTRIES DISCHARGING TO THE KAMINISTIKWIA RIVER

WASTE FLOW AND LOADINGS (1969-1970)

Receiving Basin	Industry	Flow (MGD)	BOD_5 (#/day)	Suspended Solids (#/day)		Status of Treatment Program
Kam River	Industrial Grain Products, Limited	0.3	26,300	15,800		No treatment at present - The Company is installing a new process system that features recirculation of waste water- wastes from this system would be acceptable for disposal to the Municipal sewerage system- to be completed by the end of 1971.
	Dow Chemical of Canada, Limited	4.2	Negligible		Mercury - 0.2 #1 day	Present Treatment - - Chemical treatment and settling lagoon. - Holding tank for major spills. - Land disposal of sludge.
	Canadian Pacific Railway	CPR discharges a mixture of oil spillages and run-off water				Present Treatment -Oil separator(1) - Company has agreed to install more oil separators
	The Great Lakes Paper Co. Ltd.	60	360,000	168,500		Present Treatment-Primary treatment of Kraft Mill wastes - The Company is installing two mechanical clarifiers for the removal of suspended solids. - Timing of complete secondary treatment program being reviewed by OWRC.

APPENDIX VIII - KAMINISTIKWIA RIVER WATERSHED

LOCATION OF HYDRO DAMS AND GENERATING STATIONS



Appendix

Traced from Map No. 23A, Thunder Bay District, Dept. of Lands & Forests

Province of Ontario

APPENDIX IX - TABLE (a)

KAMINISTIKWIA WATERSHED

FLOW (cfs) SUMMARY - 1970

Month	Silver Falls			Shebandowan			Kakabeka Falls		
	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
July	34	742	1,262	30	132	220	1,413	1,150	2,427
August	31	490	1,206	3	13	32	205	743	1,833
September	57	362	1,013	Dam Closed 15	15 Leakage	15	257	562	1,066

APPENDIX IX - TABLE (b)

KAMINISTIKWIA RIVER FLOW (cfs)

SILVER FALLS

Date	July		August		September	
	1969	1970	1969	1970	1969	1970
1	372	574	1367	277		943
2	855	1165	452	396		859
3	935	1262	0	395		459
4	825	1010	252	804		1013
5	1279	800	1132	1206		736
6	1153	1092	1053	1069		503
7	857	1253	1506	910		397
8	1452	1240	843	595		87
9	1605	1036	1609	82		713
10	1809	1043	500	659		578
11	1650	983	904	802		341
12	1819	126	1524	800		229
13	645	361	1435	799		201
14	910	605	1580	692		191
15	1485	589	1616	398		311
16	1802	597	1766	31		354
17	1771	544	718	127		406
18	1341	427	1737	428		158
19	1394	379	1629	173		173
20	1051	494	1531	323		89
21	1349	436	1630	401		531
22	1318	930	1733	406		359
23	1361	894	1763	245		219
24	1337	907	1423	502		290
25	1429	455	914	256		333
26	1046	34	1336	471		205
27	1114	473	1589	592		0
28	1111	713	1257	398		0
29	1066	1096	1481	374		57
30	1523	796	1551	258		149
31	1186	710	1303			

APPENDIX IX - TABLE (c)

KAMINISTIKWIA RIVER FLOW (cfs)

KAKABEKA FALLS

Date	July		August		September	
	1969	1970	1969	1970	1969	1970
1	1923	2427	1521	1308		345
2	1926	1413	1614	1055		-
3	2151	2270	1224	885		947
4	1968	1946	1195	860		603
5	2338	1857	2451	1249		1066
6	2687	1677	2495	1833		925
7	2200	1983	3140	1189		680
8	2030	2013	2817	1193		453
9	2720	2033	2547	447		302
10	2978	1842	2339	688		855
11	2775	2121	1421	1219		790
12	2864	2062	1968	1132		660
13	2407	1660	2293	860		645
14	1253	1680	2403	860		535
15	1895	1464	2515	693		448
16	2835	1472	2593	535		438
17	2953	1419	1726	205		557
18	2631	1302	2076	240		495
19	2181	1254	2282	475		422
20	2081	1369	2171	240		337
21	2059	1282	2119	377		-
22	2186	1805	2245	475		512
23	2183	1830	2226	588		587
24	2133	1340	2270	332		515
25	2174	1473	1476	588		555
26	1921	993	1454	360		667
27	1799	810	1773	600		502
28	2028	788	1954	760		362
29	1770	1310	1738	405		266
30	2070	1444	1953	425		257
31	1841	1300	2191			

BIBLIOGRAPHY

1. "The Biological Effects of Oil Pollution in a River"

Thesis by Rita McCauley (1964) University Microfilms, Inc., Ann Arbor, Michigan

- Oil tends to lower oxygen levels and raise temperature levels - particularly in summer months.

The full effects of oil discharges to the river should be biologically determined.

2. "Wastes and Your Water Supply. Pollution and Ecological Balance"

by Bellamy, D.J. and Whitton, B.A. - Reprint, Royal Society of Health Journal V89(5):235-238 P and 256 1969

- Oxygen supply major factor which controls energy flow through any aquatic ecosystem. If, for any reason, the oxygen supply to the system became depleted the flow of energy would slow down and organic matter would begin to accumulate.

3. "The Great Lakes as an Environment"

Great Lakes Institute Report PR 39
University of Toronto, Edited by D.V. Anderson

4. "Special Report on Potential Oil Pollution, Eutrophication and Pollution from Watercraft"

by International Joint Commission, 1970

5. "Biological Survey of the Kaministikwia River and Thunder Bay, 1965-1966"

Ontario Water Resources Commission

6. "Lakehead Area Regional Water Supply and Pollution Control Study,May 1969"

Ontario Water Resources Commission

7. "Oxygen Relationships in Streams"

U.S. Department of Health, Education and Welfare, Public Health Service, 1958

8. "Storm Drainage Facilities for the City of Fort William, Ontario"

by W.L. Wardrop and Associates Ltd.
Engineering Consultants - March, 1965

9. "Determination of the Cause of Fish Kills"

by G. E. Burdick
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